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Original Article

Iot Based Smart Aquaculture Monitoring and Anchor Worm Eradtication System

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Abstract - Fish aquaculture needs to maintain optimal water quality to ensure healthy growth and productivity. An intelligent system based on Arduino is proposed in this project to monitor and regulate water parameters such as pH, turbidity, and temperature. The system consists of two motors for Bluetooth-controlled water input and outlet control, an LCD for real-time data display, and a servo motor for the automatic injection of water-quality-enhancing substances when pH levels reach critical levels. This automatic system reduces the need for manual intervention, increases monitoring efficiency, and ensures a stable aquatic environment. Other applications for the servo motor include fish feeding and the addition of potassium permanganate, which helps eradicate anchor worms. A camera will also be incorporated to keep an eye on the aquatic environment.

Keywords - Arduino,pH Regulation,Turbidity Control, Temperature Monitoring,Bluetooth Communication ,Automated System, Servo Motor, Potassium Permanganate Treatment, Real-Time Monitoring.

I. INTRODUCTION

Aquaculture, the controlled farming of fish and other aquatic organisms, has become a vital solution to meet the growing global demand for seafood while alleviating pressure on wild fish populations. Traditional fish farming methods often suffer from inefficiencies, resource wastage, and environmental concerns, necessitating the adoption of modern technologies to improve productivity and sustainability [1]. The integration of IoT (Internet of Things) in aquaculture offers an advanced management system that enables real-time monitoring, automated control, and data-driven decision-making to optimize fish health, water quality, and overall operational efficiency.

With the increasing global population, seafood consumption has risen significantly, making aquaculture a key player in food security and economic stability [2]. However, traditional fish farming is labor-intensive and prone to human error, leading to inconsistencies in water quality management, feeding schedules, and disease prevention. Moreover, environmental concerns such as water pollution, excessive feed waste, and ecosystem degradation highlight the need for a smarter, automated system to maintain sustainability. A well-implemented fish aquaculture management system can address these challenges by ensuring optimal water parameters, monitoring fish behavior, automating feeding systems, and detecting early signs of disease outbreaks. The need for such a system stems from the requirement to enhance productivity while reducing operational costs and mitigating ecological impacts [3].

Despite the growing advancements in aquaculture, many fish farms still rely on outdated, manual monitoring techniques, leading to inefficiencies in resource utilization and increased fish mortality rates. Key challenges faced by fish farmers include inconsistent water quality management, where oxygen levels, pH, ammonia concentration, temperature, and turbidity fluctuate frequently, making manual monitoring unreliable and time-consuming. Overfeeding or underfeeding due to the lack of automated feeding mechanisms often results in wasted feed, higher operational costs, and poor fish health. Delayed disease detection is another major issue, as early detection of infections is crucial for preventing widespread outbreaks that can cause severe economic losses. High labor costs and human dependency make traditional fish farming expensive and inefficient. Additionally, environmental impact and resource wastage due to excess feed, untreated wastewater, and overuse of antibiotics can severely damage aquatic ecosystems [4]. Addressing these issues requires an integrated technological approach to streamline operations, reduce waste, and improve overall farm productivity.

The deployment of an automated fish aquaculture management system involves the use of various hardware components that work together to monitor and control the fish farming environment efficiently. The key hardware components include water quality sensors that measure essential parameters such as dissolved oxygen, pH levels, temperature, ammonia, and nitrate concentrations to ensure optimal water conditions for fish growth. IoT-enabled microcontrollers such as Arduino act as the central processing units, collecting sensor data and triggering necessary actions based on predefined thresholds. Automated feeding systems dispense appropriate feed amounts based on fish behavior and appetite detection mechanisms. Aerators and water circulation systems regulate oxygen levels in real time to maintain a healthy aquatic environment. Surveillance cameras equipped with AI algorithms monitor fish behavior, detect anomalies, and help in the early diagnosis of diseases. Wireless communication modules, including Wi-Fi, LoRa, and GSM, enable real-time remote monitoring and control by transmitting data to cloud platforms or mobile applications. By implementing these hardware solutions, fish farmers can automate their operations, reduce human dependency, and optimize the overall aquaculture process [5].

The Internet of Things (IoT) plays a crucial role in transforming traditional fish farming into a modern, data-driven industry. The IoT-based fish aquaculture management system integrates various sensors, cloud platforms, and automation techniques to provide real-time monitoring and control. The key aspects of IoT-based management include real-time monitoring, where IoT-enabled sensors continuously monitor water quality parameters, providing live data to farmers through mobile apps or cloud dashboards. Automated decision-making using AI-driven analytics helps predict environmental fluctuations and adjust aeration, feeding, and filtration systems accordingly. Data analytics and predictive maintenance allow for historical data analysis, enabling predictive maintenance of equipment, reducing downtime, and improving operational efficiency. Remote accessibility ensures that farmers can access and control their aquaculture systems from anywhere, receiving alerts and notifications for any abnormal conditions. Blockchain technology can be integrated to ensure transparency and traceability in fish production, improving market trust and regulatory compliance. Sustainability and waste management are enhanced by optimizing feed usage and monitoring water quality, contributing to environmentally friendly aquaculture practices. Incorporating IoT into fish farming enhances productivity, minimizes risks, and ensures a sustainable approach to aquaculture. The combination of hardware components and IoT-driven automation leads to a smarter, more efficient, and profitable fish farming industry.

The adoption of a Fish Aquaculture Management System is essential for modernizing fish farming operations, improving efficiency, and ensuring environmental sustainability. By leveraging IoT, automation, and advanced hardware solutions, fish farmers can overcome traditional challenges and optimize resource utilization. The integration of real-time monitoring, AI-driven decision-making, and predictive analytics provides an innovative approach to sustainable aquaculture management, reducing operational costs and enhancing fish health. As the demand for seafood continues to rise, implementing smart aquaculture solutions will play a pivotal role in meeting global food security needs while protecting aquatic ecosystems.

II. RELATED WORKS

Li Xiaoman et al. [6] propose a wireless environmental monitoring system for aquaculture using ZigBee technology. The system includes a hardware and software framework for sensor nodes and a communication network. It features RF ZigBee transceivers, communication modules, and PCB fabrication for reliable data transmission. The software component ensures seamless data processing and control, making remote monitoring effective.

M. A. Kumar et al.[7] implement IoT technology for aquaculture management using sensors like temperature, water level, and pH sensors. These parameters are crucial for maintaining water quality, and any deviations trigger automatic responses. A GSM module sends alerts to users about abnormal readings, ensuring proactive management. The system also features an LCD display for real-time data visualization.

C. Dupont et al. [8] explore smart and efficient IoT tools for fish farming, emphasizing affordability, ease of deployment, and reliability. Artificial Intelligence enhances data processing, offering new solutions for sustainable aquaculture. The study highlights research projects that lay the foundation for Aquaculture 4.0. The approach aims to integrate automation with eco-friendly practices.

Bo Chang et al. [9] use the CC2530 chip to develop ZigBee-based wireless sensor nodes for aquaculture monitoring. The system collects environmental data in real time and employs a fuzzy PID control algorithm for improved accuracy. It effectively monitors dissolved oxygen, temperature, and pH, reducing energy consumption and latency. The system enhances automation and precision in aquaculture management.

Y. Chen et al. [10] propose a wireless sensor network (WSN)-based system for monitoring water quality in factory aquaculture. The system comprises sensor nodes, ZigBee communication, and a central processing unit. Hardware and software designs ensure effective data collection and transmission. Experimental results demonstrate the system’s efficiency in monitoring key water quality parameters.

Y. Fu et al. [11] develop an intelligent ZigBee-based monitoring system for mariculture water quality. It includes data acquisition, transmission, and an early warning mechanism to detect anomalies in temperature, pH, and oxygen levels. A ZigBee coordinator node processes and transmits real-time data via GPRS. The system enables remote monitoring and timely intervention to maintain water quality.

N. Thai-Nghe et al. [12] propose an IoT-based system for monitoring and forecasting water quality in aquaculture. Their approach analyzes data from real-time monitoring systems to predict quality variations. The system is tested on datasets to validate its effectiveness in real-world applications. Results indicate its potential for accurate and proactive aquaculture management.

F. L. Valiente et al. [13] introduce an IoT-based alert system for monitoring tilapia behavior using multiple sensors. The system tracks pH, temperature, turbidity, oxygen levels, water level, and TDS, providing real-time alerts via the Blynk application. An automated fish feeder enhances efficiency, improving fish growth rates. Results show the system significantly impacts aquaculture productivity.

Y. Ma et al. [14] design an intelligent dissolved oxygen (DO) monitoring system for aquaculture. Using optical and polarographic sensors with NB-IoT and PLC technologies, the system ensures optimal DO levels. Automated monitoring reduces human intervention and improves efficiency. Experimental tests confirm the system's accuracy in maintaining water quality and reducing power consumption.

Z. Shareef et al. [15] develop a water quality monitoring system for aquaculture farms in the Western Godavari region. The study includes a network analysis to optimize sensor node placement for efficient coverage. The system ensures comprehensive environmental monitoring through sensor-based data collection. The research enhances aquaculture management by improving data-driven decision-making.

T. Joseph et al. [16] utilize a microcontroller-based system for real-time water quality monitoring. Sensors measure temperature, pH, electrical conductivity, and dissolved oxygen, transmitting data to a database for analysis. The system achieves high accuracy and precision in environmental parameter measurement. Results indicate reliable data processing for better aquaculture management.

Minghu Wu et al. [17] introduce a multi-parameter aquaculture monitoring system using the Profibus-DP field bus. The system supports distributed real-time monitoring and data processing. It improves accuracy, stability, and scalability while reducing operational costs. The study demonstrates the system’s effectiveness in large-scale aquaculture enterprises.

M. Lafont et al. [18] design a water quality monitoring system integrating GIS and IoT technology. The system remotely monitors and manages key parameters like temperature, pH, and dissolved oxygen. It enables proactive intervention to maintain optimal conditions for aquatic species. The approach aligns with national policies for agricultural technology advancement.

B. Shi et al. [19] develop a fuzzy PID-controlled wireless sensor network for aquaculture. The system monitors and regulates dissolved oxygen levels using a cluster-based network topology. Experimental results show faster response times and improved accuracy compared to conventional PID systems. The system ensures reliable communication and precise environmental control.

III. MATERIALS AND METHODS

Maintaining optimal water quality is a critical aspect of aquaculture, as it directly affects the health and growth of aquatic species. Traditional methods for monitoring and maintaining water quality require frequent manual inspections and interventions, which can be labor-intensive, error-prone, and inefficient. To overcome these challenges, an intelligent water quality monitoring and control system using Arduino is proposed. This system integrates various sensors, actuators, and communication modules to automate the monitoring and regulation of key water parameters such as pH, turbidity, and oxygen. The primary objective of this system is to enhance the efficiency of aquaculture operations by reducing manual efforts and ensuring a stable aquatic environment for fish farming.

A. System Overview

The proposed system is designed to provide real-time monitoring and automatic control of water quality parameters. An Arduino microcontroller serves as the central processing unit, interfacing with multiple sensors to continuously measure critical water parameters. If any parameter exceeds the predefined threshold values, the system initiates corrective actions, such as activating water inlet and outlet motors to regulate the water exchange or using a servo motor to dispense corrective agents for pH balancing. Additionally, a Bluetooth module allows remote monitoring and control via a mobile application, and an LCD screen displays real-time data for user reference.

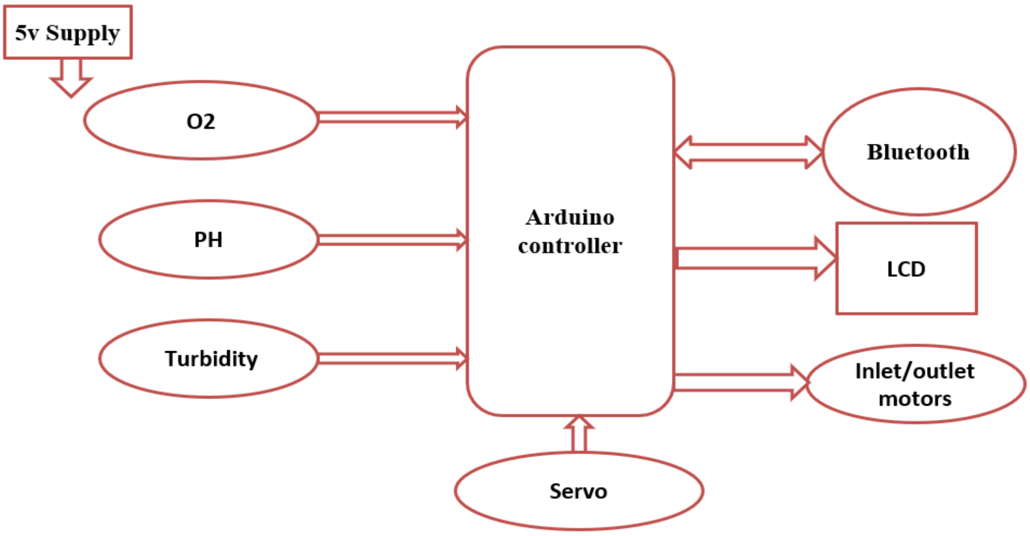

Figure 1. Proposed Block Diagram

B. Components and Their Functionality

The system utilizes various sensors to measure key water parameters continuously. The role of each sensor is as follows:

pH Sensor: This sensor is used to measure the acidity or alkalinity of the water. Maintaining the appropriate pH level is essential for aquatic species' survival, as extreme variations can lead to stress, disease, or even death. The Arduino controller continuously monitors pH values and triggers corrective actions when required.

oxygen Sensor: oxygen plays a vital role in fish metabolism and overall health. The sensor measures water oxygen, ensuring it remains within the optimal range for the specific species being cultivated. If the oxygen is off, users are alerted to take necessary actions.

Turbidity Sensor: This sensor detects the clarity of water by measuring the level of suspended particles. High turbidity can indicate contamination, algae growth, or excessive waste accumulation. The system monitors turbidity levels and activates water exchange mechanisms if the water clarity deteriorates beyond acceptable levels.

Arduino Microcontroller as the Central Processing Unit

The Arduino board acts as the brain of the system, processing sensor data in real time and executing predefined logic based on the readings.

It continuously evaluates the input data and determines whether any parameter deviates from the optimal range.

Upon detecting an anomaly, it triggers appropriate actions, such as activating motors for water exchange or controlling the servo motor for pH balancing.

The Arduino is programmed to handle multiple inputs and outputs simultaneously, ensuring seamless automation of the monitoring and control process.

Actuators for Automated Control

To automate the regulation of water quality parameters, the system includes the following actuators:

Water Inlet and Outlet Motors: Two motors are used to regulate the inflow and outflow of water. If turbidity or pH levels cross the predefined thresholds, the system activates these motors to flush out contaminated water and introduce fresh water.

Servo Motor: The system incorporates a servo motor to dispense corrective solutions, such as pH-balancing chemicals, when required. If the pH sensor detects an imbalance, the servo motor releases a predetermined amount of corrective liquid to restore equilibrium.

Communication and User Interface

Bluetooth Module: This module enables remote monitoring and control via a mobile application. Users can receive real-time alerts and manually override the system when necessary.

LCD Display: The LCD screen provides instant feedback on water quality parameters, ensuring that users can monitor conditions at a glance without needing a connected device.

C. System Operation

The proposed system operates in a structured manner to ensure efficient monitoring and regulation of water quality parameters. The following steps outline its functionality:

Data Collection: Sensors continuously measure pH, temperature, and turbidity levels and transmit the readings to the Arduino microcontroller.

Data Analysis: The Arduino processes the data and compares the readings against predefined threshold values to assess water quality.

Decision Making: Based on the analyzed data, the Arduino determines whether corrective actions are necessary. If parameters are within acceptable limits, the system continues monitoring without intervention.

Corrective Actions: If any parameter exceeds the threshold, the system initiates appropriate actions:

Activates inlet and outlet motors to regulate water exchange and maintain water clarity.

Triggers the servo motor to dispense corrective chemicals for pH balancing.

Sends alerts via Bluetooth to notify the user of abnormal conditions.

User Interaction: Users can view real-time data on the LCD display or access system updates remotely through the Bluetooth-connected mobile application.

Continuous Monitoring: The system operates continuously to ensure a stable and healthy aquatic environment.

IV. RESULT AND DISCUSSION

The results and discussion focus on the implementation of an Arduino-based aquaculture monitoring system using an embedded C program. The Arduino controller acts as the central processing unit, handling data collection, processing, and response mechanisms. Various sensors, including temperature, pH, and dissolved oxygen sensors, are integrated with the Arduino to monitor critical water parameters. The system operates on a 5V adapter, ensuring a stable power supply to all connected components. Sensor readings are continuously processed by the embedded C program, which is designed to analyze variations in water quality parameters. The collected data is displayed on an LCD screen, providing real-time feedback for users to monitor changes instantly. The LCD interface enhances usability by presenting clear and accurate readings, allowing for quick decision-making. If any parameter exceeds predefined thresholds, the system triggers necessary actions, such as turning on an aerator or sending alerts to the user. The embedded C code ensures efficient communication between the sensors and the controller, optimizing data acquisition and response time. The system's performance is validated through experimental tests, demonstrating its accuracy and reliability in monitoring water conditions. By automating the monitoring process, the Arduino-based system reduces human intervention and enhances aquaculture management, leading to improved water quality and fish health.

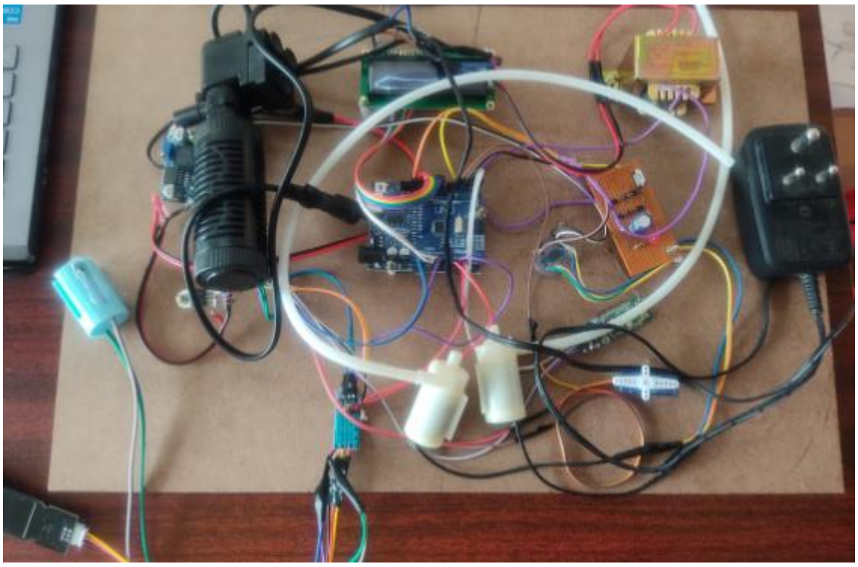

Figure 2. Hardware Set Up

V. CONCLUSION

Maintaining optimal water quality is essential for successful fish aquaculture, as it directly impacts fish health, growth, and overall productivity. Traditional water monitoring methods require constant manual supervision, which can be time-consuming and inefficient. The proposed intelligent water quality monitoring system addresses these challenges by automating the monitoring and regulation process using Arduino and various sensors.

This system continuously tracks key parameters such as pH, turbidity, and oxygen levels, ensuring that water conditions remain within ideal ranges. The inclusion of two water pumps facilitates controlled water inlet and outlet operations, which are managed via Bluetooth for remote access. A servo motor is integrated to automatically dispense water-quality-enhancing solutions when pH levels become critical, reducing the risk of harmful fluctuations. Additionally, an LCD provides real-time data visualization, allowing users to monitor water conditions effortlessly.

A crucial feature of this system is the continuous monitoring of oxygen levels. If the oxygen level falls below the required threshold, the system immediately indicates this on the LCD, alerting the user to take necessary actions. By automating these processes, the system significantly reduces the need for manual intervention, enhances operational efficiency, and ensures a stable aquatic environment.

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